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PATENTS ABSTRACTS OF JAPAN, vol. 6, no. 54 (C-97)932r, 9th April 1982; & JP - A - 56 166 957 (ASAHI KASEI KOGYO K.K.) 22-12-1981

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Description

Background of the invention

Field of the invention

The invention relates to a sealless centrifuge tube assembly for use in a centrifuge for human blood or other separable fluid suspensions, and the preferred embodiment described hereinafter concerns a tube assembly system which is inexpensive, easy to load, detachable and disposable.

Description of the prior art

Sealless blood centrifuges may be characterized as 2ω-centrifuge-rotor-on-1ω-tube- rotor, or simply as 2ω centrifuges. In such sealless 2ω centrifuges, a supply tube is held stationary at one end axially above the 2ω rotor and the center of rotation of the 1ω tube rotor. From the stationary end, the supply tube follows an off-axis hook-shaped path round the outside of the centrifuge via the tube rotor, and the opposite end of the supply tube enters the centrifuge rotor from below along the axis and is connected to the centrifuge rotor. The supply tube sweeps a closed path at a rotational speed of 1ω while the centrifuge rotor rotates at 2ω in the same direction. During centrifuge operation the supply tube flexes at various points, and rotates about its own axis as it passes, off-axis, via the tube rotor, as see e.g. Patents Abstracts of Japan, Vol. 6, No. 54 (C-97) [932], 9th April 1982 and JP—A—56166957.

Blood centrifuges may operate with a number of separable supply tubes (or tube channels known as lumens) in order to process various blood components. Such multilumen centrifuge systems normally require either a multichannel rotating seal, such as used with the IBM 2997 Blood Separation Channel, oc are limited to relatively low rotational speeds to eliminate the destructive heat associated with rotational and flexure friction.

U.S. Patent 4,114,802, R. I. Brown, "Centrifugal Apparatus with Biaxial Connector" shows a connection member driven synchronously with the rotation of tubing or umbilical cable about its own axis.

U.S. Patent 3,986,442, Khoja et al, "Drive System for a Centrifugal Liquid Processing System" shows a guide tube rotating at −ω which is used to minimize friction between the guide tube and the cable. The guide tube has its axis parallel to the system axis.

U.S. Patent 4,056,224, H. Lolachi, "Flow System for Centrifugal Liquid Processing Apparatus", shows a 2ω sealless centrifuge in which the supply tube is essentially unsupported except for guide members which provide positioning with respect to the rotor. Figure 8 of the same patent shows a guide tube which is provided as a loading guide for insertion of a loading cord. The loading cord is pulled through the guide tube and in turn pulls the blood bag into the centrifuge bowl.

U.S. Patent 3,358,072, E. R. Wrench, "Coupling", shows a hollow shaft and hollow bevel gear arrangement by which a supply tube is coupled to a 2l sealless centrifuge.

U.S. Patent 2,135,835, K. Papello, "Device for Transmitting Electric Currents", shows a somewhat similar device by which a set of electrical cables is connected to a rotor within a rotating bowl.

Summary of the invention

The preferred embodiment of the invention is a limited use, disposable, inexpensive, partially self-supporting processing channel and tube system for use with a 2ω sealless centrifuge. Such a limited use system is especially valuable in sterile applications related to human blood separation activities with the patient or donor "on the system" contributing or receiving a blood fraction while connected with a significant flow of blood through the system and back to the patient or donor.

In a 2ω sealless centrifuge, the limited use processing channel and lumen tube system is mounted with the processing collar formed on a centrifuge rotor which is rotating at 2ω on a platform rotor rotating at 1ω. The lumen tube is prevented from twisting by driving it, by the rotor, in the same direction as the centrifuge 2ω rotor around the 2ω rotor, at a speed of 1ω. As a result, the lumen tube flexes about its own axis in the direction of the processing channel and 2ω rotor rotation at a speed of −1ω with respect to the support bearing on the periphery of the 1ω rotor. The lumen tube encounters stresses due to centrifugal force and due to drive forces from two drive bearing support points on the 1ω rotor. The unreinforced central portion on the lumen tube, supported by centrifugal force, extends in two reinforced portions, the first between the processing channel clamp on the 2ω rotor and a first bearing support point on the 1ω rotor, and the second between the stationary clamp and a second bearing support point on the 1ω rotor. In the reinforced portions, the lumen tube is mounted within a surrounding reinforcing sleeve. Lumen tube and reinforcing sleeve flex as a unit. The processing channel and clamp are fixed axially to the 2ω rotor so as to rotate with the 2ω rotor. The 1ω rotor, a support platform and bail rotating at 1ω includes a pair of reinforcing sleeve receivers at the bearing support points. The reinforcing sleeves end in reinforcing sleeve thrust drive bearings, with each of the reinforcing sleeve portions extending between a clamp and the respective reinforcing sleeve thrust drive bearing. The respective thrust drive bearings mate with related reinforcing sleeve receivers on the 1ω rotor. Each reinforcing sleeve receiver has a slot, of sufficient size with respect to the expected unsupported lumen tube, to allow side entry of the lumen tube but not of the reinforcing sleeve or thrust drive bearing. When mounted in the centrifuge drive, the lumen tube flexes freely between the reinforcing sleeve receivers, while the 2ω rotor turns. The lumen tube flexes but does not actually rotate a complete revolution. The

processing channel may be served by multiple lumens so as to provide multiple separation operations during the same spin as required by blood fractionating processes. The lumen tube within each of the two reinforcing tubes flexes less freely because of the constraints of the reinforcing sleeves which are clamped in a prestressed curve in relationship to their respective reinforcing tube receivers and their respective clamps.

A preferred object of the invention is to provide an inexpensive, easy to use, readily attachable and detachable limited use and disposable, sterile tube assembly for a centrifuge.

By providing thrust bearings on the tube assembly, one avoids the need to thread any part of the tube assembly through thrust bearings of the centrifuge when mounting the tube assembly on the centrifuge. A sterile tube assembly can be provided in a sterile pack, and an operator does not need to dismantle the tube assembly before attaching it in place on the centrifuge—such dismantling would potentially break sterility—and the sterility of the interior of the tube assembly can be readily and easily assured until the last moment when terminal connections are made to it.

Brief description of the drawings

Figure 1 is a diagrammatic drawing showing, in accordance with the invention, a tube assembly in a sealless 2ω centrifuge.

Figure 2 is an enlarged, exploded and partially cutaway detail diagram illustrating a bearing arrangement of Figure 1.

Figure 3 is a detail cross-section of the assemled bearing arrangement of Figure 2.

Figure 4 is a diagram of another tube assembly of the invention.

Description of the preferred embodiment

Figure 1 shows diagrammatically a limited use partially self-supported processing channel and tube system in place in a 2ω sealless continuous flow centrifuge drive. The centrifuge drive includes 1ω rotor 1, which carries 2ω rotor 2, supplied by the processing channel and tube system. The processing channel and tube system includes lumen tube portion 3 and other components which form the system 4. Lumen tube 3 is supported by a first reinforcing sleeve 5 between processing channel clamp point 6 and thrust drive bearing 7. Lumen tube 3 is also supported by a second reinforcing sleeve 8 mounted between stationary clamp point 9 and thrust drive bearing 10 on 1ω rotor 1. The first reinforcing sleeve 5 via bearing 7 fits in reinforcing sleeve receiver 11 on 1ω rotor 1 while the second reinforcing sleeve 8 fits via bearing 10 in reinforcing sleeve receiver 12 at another point on 1ω rotor 1.

In operation, 1ω rotor 1 is provided with a 1ω spin by a drive 27 and the 2ω rotor 2 is provided with a 2ω spin in the same direction by means not shown. The lumen tube 3 flexes with its reinforcing sleeves 5 and 8, with a portion of the lumen tube configured by centrifugal force in the otherwise unsupported portion between reinforcing sleeve receivers 11 and 12.

General characteristics of the 2ω sealless centrifuge are merely context for the invention, although the 1ω rotor must be configured with appropriate reinforcing sleeve receivers 11, 12 to fit the limited use partially self-supported processing channel and tube system of the invention.

Figure 2 is a partially cutaway detail diagram illustrating the relationships between the limited use, partially self-supporting processing channel and tube system and the reinforcing sleeve receiver of the centrifuge drive.

Figure 3 shows detail of one of the reinforcing sleeve thrust drive bearings. Lumen tube 3 is supported by second thrust drive bearing 10 and by second reinforcing sleeve 8, which is press fit with its outside diameter slightly smaller than the inside diameter of the housing of bearing 10. Cement may be used as required.

Drive power is imparted (from drive 27, Figure 1) by second reinforcing sleeve receiver 12 in the direction normal to the page; receiver 12 and slotted coneholder 13 at the same time fix reinforcing sleeve 8 longitudinally because of the beam strength of reinforcing sleeve 8 and because of centrifugal force. Lumen tube 3 is fixed to reinforcing sleeves 5 and 8 at thrust drive bearings 7 and 10, respectively, by cement of sufficient strength to prevent rotation of lumen tube 3 inside the reinforcing sleeves 5 and 8.

Drive forces are imparted from drive bearing slider cone 15 to axle surface 14 of thrust drive bearing 10. The bearing 10 is urged by centrifugal force acting on the tube 3, and by additional pressure on thrust bearing surface 16 caused by the compression of reinforcing sleeve 8, to a snug fit within slotted coneholder 13. A small lip forms bearing cone retainer 17. Bearings 7 and 10 are identical.

Note that these inexpensive bearings (7, 10, Figure 1) are to be operated at speeds of 1ω, which in the preferred embodiment may be 1200 rpm. Gravity forces of approximately 1,000 G are effective at the processing channel; forces of greater than 250 G act at the bearing as a result of centrifugal force alone. Other bearing load comes from the continual flexing which is not without aberration both cyclical and random. Initial sterilization makes hydrocarbon lubrication inpropriate, and especially heat from operational friction (both rotational and flexure) is significant. The plastic reinforcing sleeves (5, 8, Figure 1) are a source of heat due to flexure; they are not effective to cool the bearings. The bearing slider cones (15, Figures 2 and 3) are most effectively cooled by good contact to their respective coneholders (13, Figures 2 and 3). The cones are preferably of a good heat transfer material such as aluminum. Note that air cooling of the coneholder is inherent because of the centrifuge rotation, but the normal heat buildup within the centrifuge housing may keep even the cooling air at an

elevated temperature. Bearing slider external configurations other than conical can be used, with appropriate complementary configurations of the coneholder, but conical configuration is preferred.

The lumen tube 3 itself heats up due to flexure. The reinforcing sleeves (5, 8) control this flexure within bounds, and distribute the flexure and also the heat so as to avoid weakened hot spots. The unsupported medial portion of lumen tube 3 is air cooled and also is relatively free from aberrations. It flexes freely in rotational mode (partial rotations) but is held by enormous G-forces in a smooth curve between the two thrust drive bearings.

Figure 4 illustrates in more detail a tube assembly for use in a 2ω sealless centrifuge. Locator rings 18 and 19 affixed to the respective reinforcing sleeves 5 and 8 are available for clamping by clamps (not shown) (at 9 and 6 Figure 1) of the centrifuge drive.

Processing channel 20 is arranged to fit on the 21 rotor (2, Figure 1) for high speed rotation at 2ω in the preferred embodiment 2400 rpm.

Thrust drive bearings 7 and 10 are arranged to fit reinforcing tube receivers 11 and 12, respectively, as shown in Figures 2 and 3. Distribution plumbing 21, distribution lumen tube separations 22, and processing manifold 23 are configured appropriately for the desired separations 24. Where appropriate, further plumbing within the closed system can be integrated in distribution plumbing 21. The further plumbing normally includes tubes for use with peristaltic pumps and input and output tubes. Processing manifold 23 can take a number of different forms as desired. Connections for saline solutions for precharge and other uses may also be integrated.

The system in the preferred embodiment is configured of the following materials:

Lumen tubes—polyvinyl chloride
Reinforcing tubes—polyvinyl chloride
Thrust bearing—acetal plastic
packed with polyester for lubrication
Bearing cone—aluminum.

Other materials, dimensional variations and appropriate selection of fractionating choises may be substituted. Note that the plastic parts are subjected, during their relatively short duration of actual use (minutes or hours) to temperature changes from room temperature to high frictional heat, to forces of from 1 to 1,000 G and pressures up to 8 kilograms per square centimeter.

If the whole of the lumen tube had been provided with reinforcing tubing such as 5 and 8, the centrifugal force on the part between the bearings would be correspondingly greater, which would make the satisfactory design of inexpensive, limited-use low-load bearings more difficult, and would reduce air cooling via the lumen tube.

The tube assembly of Figure 4 is detachable and disposable as a unit, and the features of the centrifuge drive mechanisms will be readily apparent which allow the tube assembly to be used as follows. Initially, the elements 21, 8 and 5 are passed down through an axial passage in the rotor 2, and through an opening (not shown) in the side wall of the rotor 1, to allow the channel 20 and manifold 23 to be fitted to the centrifuge rotor 2. The dimensions illustrated in Figure 4 are relatively enlarged for clarity see e.g. channel 20 as shown in Figure 1. Bearings 7 and 10 are then fitted laterally into receivers 11 and 12 of rotor 1. Element 21 is then passed through a fixed casing, where ring 18 is clamped, and is mounted on a stationary feed terminal (not shown). In Figure 1 the drive 27 for the rotor 1 is shown, but any suitable drive for rotors 1 and 2 can be used which ensures that rotor 2 rotates at twice the speed and in the same direction as rotor 1. Suitable gear drivers are known see for example the prior art already mentioned, and IBM TDB's to be published about March 1984, both by A. P. Mulzet, and entitled respectively Drive Mechanism for Sealless Centrifuge, and Sealless Centrifuge Drive Mechanism.

Claims

1. A tube assembly for a 2ω sealless centrifuge, said tube assembly having a lumen tube (3), and first and second spaced thrust bearings (7, 10) on the lumen tube for supporting the lumen tube when it is subjected in operation to centrifugal force, while allowing rotation of the lumen tube about its own axis in said bearings, each said bearing including a housing (8, 10, 14) that is fixed with respect to said lumen tube and a bearing slider (15) that is mounted on said housing for rotation with respect to said housing.

2. A tube assembly as claimed in Claim 1 in which said lumen tube, beyond said bearings, is encased in first and second spaced reinforcing tubes (5, 8).

3. A tube assembly according to Claim 2 in which the reinforcing tubes are cemented to the adjoining sections of the lumen tube.

4. A tube assembly as claimed in Claim 2 or 3 in which the reinforcing tubes have locators (18, 19) at the ends thereof opposite said bearings.

5. A tube assembly according to any of Claims 2 to 4, wherein said first and second thrust drive bearings each comprise a bearing slider (15) and a housing (10) having socket, thrust bearing surface (16), axle bearing surface (14) and retainer (17), and are made of low friction material, said housing being mounted with a respective reinforcing tube (5, 8) fixed in its socket and with said bearing slider mounted on said axle bearing surface in contact with said thrust bearing surface and retained in place by said retainer.

6. A tube assembly as claimed in Claim 5 in which said bearing sliders are conical in configuration, with the point of the cone in the direction of expected centrifugal force.

7. A tube assembly as claimed in any preceding claim in which the lumen tube is connected at one

end to a channel (20), which in operation, is located at and rotates with the centrifuge 2ω rotor.

8. A tube assembly as claimed in any preceding claim in which the lumen tube is connected at one end to a distribution plumbing element (21) which in operation is stationary.

9. A 2ω sealless centrifuge including a tube assembly as claimed in any preceding claim, and in which the 1ω tube rotor (1) includes bearing receivers (11, 12) into which said bearings (7, 10) of the tube assembly can be laterally located without dismantling the tube assembly.

Patentansprüche

1. Schlauchaufbau für eine dichtungslose 2ω-Zentrifuge, mit einem Lumenschlauch (3) und ersten und zweiten voneinander beabstandeten Axialdrucklagern (7, 10) auf dem Lumenschlauch zum Tragen des Lumenschlauches, wenn dieser beim Betrieb einer Zentrifugalkraft ausgesetzt ist, während dem Lumenschlauch in den Lagern eine Rotation um seine eigene Achse erlaubt ist, wobei das Lager ein Gehäuse (8, 10, 14), das bezüglich des Lumenschlauches feststehend ist, und ein Lagergleitstück (15), das auf dem Gehäuse zur Drehung bezüglich des Gehäuses angebracht ist, enthält.

2. Schlauchaufbau nach Anspruch 1, wobei der Lumenschlauch jenseits der Lager von ersten und zweiten, voneinander beabstandeten Verstärkungsschläuchen (5, 8) ummantelt ist.

3. Schlauchaufbau nach Anspruch 2, wobei die Verstärkungsschläuche mit den angrenzenden Abschnitten des Lumenschlauches verklebt sind.

4. Schlauchaufbau nach Anspruch 2 oder 3, wobei die Verstärkungsschläuche an ihren den Lagern gegenüberliegenden Enden Anbringungsmittel (18, 19) aufweisen.

5. Schlauchaufbau nach einem der Ansprüche 2 is 4, wobei die ersten und zweiten Axialdrucklager jeweils ein Lagergleitstück (15) und ein Gehäuse (10) mit einem Sockel, einer Axialdrucklagerfläche (16), einer Achslagerfläche (14) und einem Halteteil (17) aufweisen und aus einem Material mit niedriger Reibung gefertigt sind, wobei das Gehäuse mit einem jeweiligen in dessen Buchse befestigten Verstärkungsschlauch (5, 8) und mit dem auf der Achslagerfläche in Kontakt mit der Axialdrucklagerfläche befestigten Lagergleitstück angebracht und durch das Halteteil an seinem Platz gehalten ist.

6. Schlauchaufbau nach Anspruch 5, wobei die Lagergleitstücke einen konischen Aufbau haben, bei dem die Spitze des Konus in Richtung der erwarteten Zentrifugalkraft liegt.

7. Schlauchaufbau nach einem der vorhergehenden Ansprüche, wobei der Lumenschlauch an einem Ende mit einem Kanal (20) verbunden ist, der beim Betrieb auf dem Rotor der 2ω-Zentrifuge angeordnet ist und mit diesem rotiert.

8. Schlauchaufbau nach einem der vorhergehenden Ansprüche, wobei der Lumenschlauch an einem Ende mit einer Verteilungsarmatur (21) verbunden ist, welche beim Betrieb stationär ist.

9. Dichtungslose 2ω-Zentrifuge mit einem Schlauchaufbau nach einem der vorhergehenden Ansprüche, wobei der 1ω-Schlauchrotor (1) Lageraufnahmen (11, 12) enthält, in welche die Lager (7, 10) des Schlauchaufbaus ohne Unterbrechung des Schlauchaufbaus seitlich angebracht werden können.

Revendications

1. Dispositif à tube pour centrifugeuse 2ω, sans joint d'étanchéité, ledit dispositif à tube comprenant un tube de passage (3) et des premier et second paliers d'entraînement et de butée espacés (7, 10) sur le tube de passage pour supporter ce dernier quand il est soumis en fonctionnement à la force cenrrifuge, tout en permettant la rotation du tube de passage autour de son propre axe dans lesdits paliers, chacun desdits paliers comprenant un logement (8, 10, 14) qui est fixe par rapport audit tube de passage et un coulisseau formant palier (15) qui est monté dans ledit logement de façon à tourner par rapport audit logement.

2. Dispositif à tube selon la revendication 1, dans lequel ledit tube de passage est enfoncé au-delà desdits paliers dans des premier et second tubes de renfort espacés (5, 8).

3. Dispositif à tube selon la revendication 2, dans lequel les tubes de renfort sont collés par un ciment sur les sections voisines du tube de passage.

4. Dispositif à tube selon la revendication 2 ou 3, dans lequel les tubes de renfort comprennent des dispositifs de positionnement (18, 19) à leurs extrémités qui sont opposées auxdits paliers.

5. Dispositif à tube selon l'une quelconque des revendications 2 à 4, dans lequel lesdits premier et second paliers d'entraînement et de butée comprennent chacun un coulisseau formant palier (15) et un logement (10) présentant une surface d'appui et de butée en forme de douille (16), une surface d'appui axial (14) et un élément de retenue (17), qui sont réalisés en un matériau à faible coefficient de friction, ledit logement étant monté de manière qu'un tube de renfort respectif (5, 8) soit fixé dans sa douille et de manière que ledit coulisseau formant palier soit monté sur ladite surface d'appui axial qui est en contact avec ladite surface formant palier d'entraînement et de butée, et soit retenu en place par ledit élément de retenue.

6. Dispositif à tube selon la revendication 5, dans lequel lesdits coulisseaux formant paliers sont de configuration conique, la pointe du cône étant dans la direction de la force centrifuge attendue.

7. Dispositif à tube selon l'une quelconque des revendications précédentes, dans lequel le tube de passage est relié à une extrémité à une enceinte (20) qui, en fonctionnement, est positionnée sur en tourne avec le rotor 2ω de la centrifugeuse.

8. Dispositif à tube selon l'une quelconque des revendications précédentes, dans lequel le tube de passage est relié à une extrémité à un élément de boîte de distribution (21) qui est fixe pendant le fonctionnement.

9. Centrifugeuse 2ω sans joint d'étanchéité,

comprenant un dispositif à tube selon l'une quelconque des revendications précédentes, dans lequel le rotor 1ω du tube (1) comprend des éléments de réception de palier (11, 12) dans lesquels lesdits paliers (7, 10) du dispositif à tube peuvent être positionnés latéralement sans démonter le dispositif à tube.

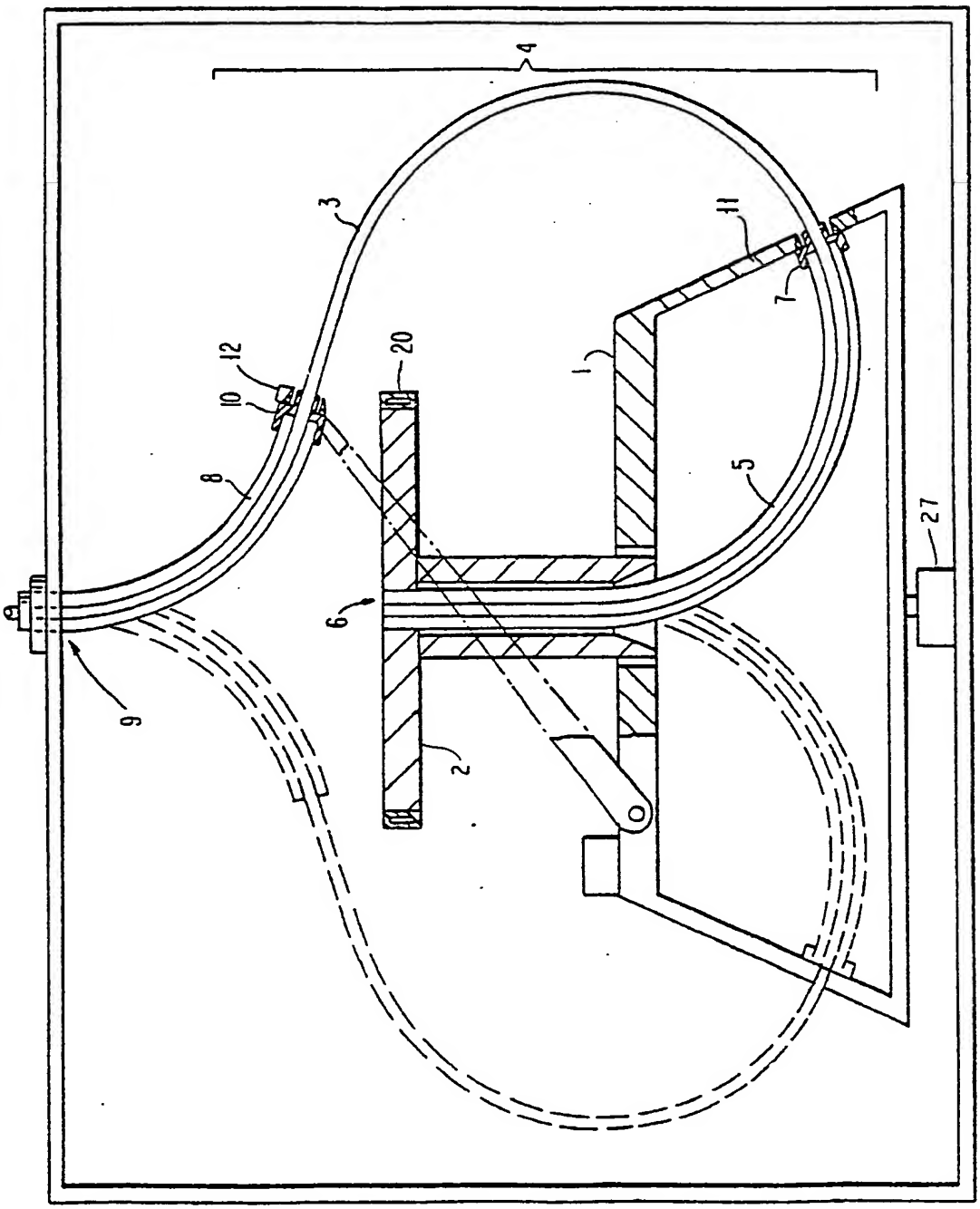

FIG. 1

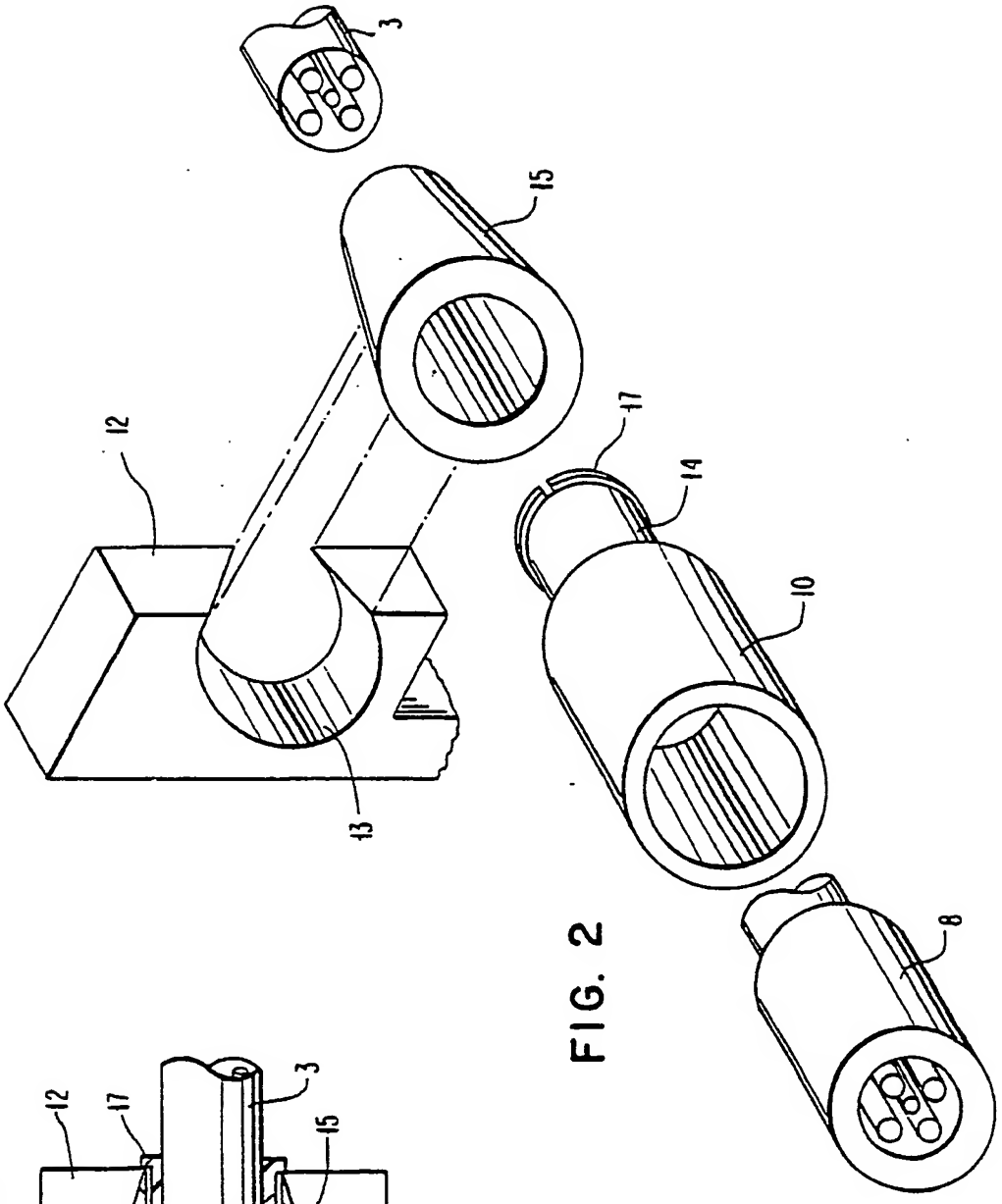

FIG. 2

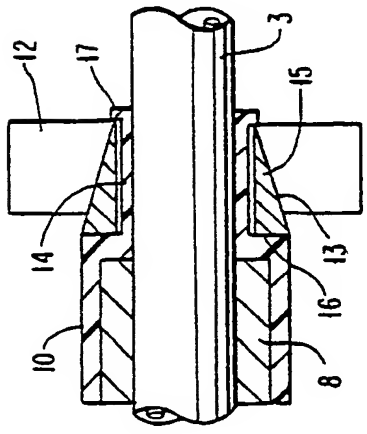

FIG. 3

FIG. 4